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LOCAL HEATING DEVICE USING CARBON NANOTUBE  
AND DIRECTION FOR ITS USE

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[Tan-so-na-no-tyu-b-reul yee-yong-han kook-soka-yul-Sook-Hui]

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Representative Figure

/2\*

Figure 1

Detailed Statement

Brief description of the figures

Figure 1 is a drawing showing a conceptual principal for the local heating device using carbon nanotube of the present invention.

Figure 2 is a drawing illustrating an example of carbon nanotube synthesis using a general catalyst.

Figure 3 is a drawing for an example of microscopic coil shaped carbon nanotube synthesis that is employed in the local heating device using carbon nanotube of the present invention.

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\* [Numbers in the right margin indicate pagination of the foreign text.]

## Detailed description of the invention

### Objective of Invention

### Existing technology and prior art

The present invention relates to a carbon nanotube (CNT) application field. Specifically, the present invention concerns a local heating device using a carbon nanotube and directions for its use. Herein, the helical microscopic coil of the carbon nanotube is inserted to the body, and the carbon nanotube can raise the temperature of a desired local section of the body by irradiating electromagnetic waves of a wavelength that can create resonance or induce electromotive force at the microscopic coil of the inserted carbon nanotube.

Today, cancer is one of the main causes for mortality. Therefore, research continues to develop treatment methods for cancer and many areas have been successful. In 2000, information on genes was uncovered. As research on this subject continues, genetic causes and treatment methods have been investigated.

At present, the three main cancer treatment methods are surgery, radiation, and anti-cancer chemotherapy. Additional cancer treatment methods include immune therapy, hormone therapy, or biological treatment. Depending on the cancer type, one method may be used and various other methods are also used in combination for the treatment. After considering the type of cancer, the location of cancer origin, the presence or absence of metastasis, the age and health of patient, and other factors, the most appropriate treatment method for the patient is chosen and used.

Cancer must be treated using the method appropriate for each individual patient after these many factors are taken into consideration. Therefore, cancer treatment is customized for each individual. Along with such a treatment, heat treatment is also performed on the basis of the following principles.

1. A malignant tumor has a weak acidic condition compared to normal tissues, and its heat sensitivity is higher under such a weak acidic condition. Therefore, tumor tissues can be damaged more easily by heat than normal tissues.
2. Blood circulation is low inside the tumor and therefore heat tends to accumulate in the tumor. Therefore, it is easier to increase the temperature of the tumor tissues than that of the normal tissues.
3. Heat can reinforce the radiation effect.
4. Heat can increase the effect of some anti-cancer agents.

Such heat treatment methods include general heat therapy and local heat therapy. Because general heat therapy increases the temperature of the whole body to 42°C and therefore increases the probability for complications, it is difficult to manage the patient's condition. Local

heat therapy can be used safely without burdening patients, and therefore local heat therapy is generally employed.

In addition, local heat therapy increases the temperature of the diseased part using electromagnetic waves including radio waves, microwaves, and ultrasound, which also can be used in combination with radiation therapy or chemotherapy. When heat therapy is performed, the tissues treated with heat therapy show resistance for heat, and thereby the effect of the second heat therapy decreases by half. However, over time, the resistance disappears. Therefore, the heat therapy usually is performed once every three days, that is, once or twice a week.

The shortcoming of this local heat therapy is in some cases the development of burn symptoms because an abnormally high temperature is produced. In other cases, the electromagnetic waves radiated during such heat therapy may not increase the temperature of cancer cells sufficiently and the desired local heating may not be achieved.

#### Technical task of invention

The present invention was created after the aforementioned conditions are taken into consideration. The present invention is designed to provide a local heating device using carbon nanotube and the direction for its use, which can increase the temperature of the desired local section by inserting the helical microscopic tube of carbon nanotube into the body and radiating electromagnetic waves of certain wavelength that can resonate with the inserted microscopic coil of the carbon nanotube or can develop a induced electromotive force.

#### Structure and effect of invention

To achieve the aforementioned objective, the local heating device using a carbon nanotube of the present invention includes a transportation means that can deliver the helical microscopic coil of carbon nanotube; and an electromagnetic wave radiating means that can irradiate electromagnetic waves of a certain wavelength and is situated in the aforementioned transportation means so that heat is generated at the local section of the body where the aforementioned transportation means is delivered.

Herein, the transportation means that places the aforementioned microscopic coil of carbon nanotube in the body is characteristically a nano-size microscopic capsule.

In addition, the aforementioned nano-size microscopic capsule is opened by heat generation of the aforementioned microscopic tube of carbon nanotube and formed to supply the contents transported by the aforementioned transportation means can also be provided in the aforementioned nano-size microscopic capsule.

The aforementioned electromagnetic wave radiating means irradiates electromagnetic waves of a certain wavelength band that can generate heat by resonating with the aforementioned

microscopic coil of carbon nanotube. The wavelength of the electromagnetic waves characteristically includes the X-ray and ultraviolet bands.

The aforementioned electromagnetic wave radiating means irradiates electromagnetic waves of a certain wavelength that can produce heat by generating induced electromotive force on the aforementioned microscopic tube of carbon nanotube. The wavelength band of the electromagnetic wave characteristically includes the far infrared ray band, microwaves, and ultrasound waves.

The helical microscopic coil of carbon nanotube that is delivered in the body by the aforementioned transportation means is formed so that chemical radicals can be attached. The chemical radicals adhered to the microscopic coil of carbon nanotube can be absorbed onto the anti-cancer agent or cancer cells.

In addition, the directions for use of the local heating device using the carbon nanotube of the present invention to achieve the aforementioned objectives includes

a step for inserting carbon nanotube microscopic coil into the transportation means that can deliver materials in the body;

a step for introducing the aforementioned transportation means into the body so that the aforementioned carbon nanotube can arrive at a certain desired region of the body; and

a step for increasing the temperature of the local region in the body by generating heat in the aforementioned microscopic coil of carbon nanotube from the irradiation of electromagnetic waves of a certain wavelength to the aforementioned microscopic coil of carbon nanotube.

The advantage of the present invention is to increase the temperature of the desired local region only by inserting the helical microscopic coil of carbon nanotube, and by irradiating electromagnetic waves of a certain wavelength that can resonate with the inserted microscopic coil of carbon nanotube or that can generate induced electromotive force.

Experimental examples of the present invention are described below in more detail using attached figure. /4

In general, the carbon nanotube has a thin and long shape with a diameter of several tens of nanometers and a length from several nanometers to several hundred nanometers. Carbon nanotubes are usually rod-shaped, but under special conditions, a carbon nanotube can be twisted to form a microscopic coil shape. This microscopic carbon nanotube coil has characteristics of a conductor, and can act as a very small helical antenna (This will be described below in the fabrication method of microscopic coil.)

Such a microscopic coil form of a carbon nanotube (or carbon nanofiber) is made in a form that can be injected into the body, for example, in a liquid mixture form, and then injected near the cancer cells. If electromagnetic waves with a wavelength that can resonate with the coil

are radiated to the diseased area, this microscopic coil can sense and react to the wave to induce electric current flow within the microscopic carbon nanotube coil.

In addition, when the electromagnetic wave with a wavelength longer than the length of the microscopic coil of the carbon nanotube enters, the magnetic field inside the coil changes and the microscopic coil of the carbon nanotube generates induced electromotive force in the opposite direction of the change and current flow is produced. When this phenomenon is interpreted by the magnetic field, the changes in the flux of the magnetic field within the microscopic coil produce a current flow which is opposite to the flux of the magnetic field and thereby form a magnetic flux which is the opposite to the flux of the magnetic field.

Such a mechanism is certainly accompanied by heat generation. In addition, other electromagnetic waves developed from such resonance or reaction can reflect or form an electromagnetic wave with a new wavelength. Figure 1 shows the conceptual principle of a local heating device using the carbon nanotube of the present invention.

The length of the carbon nanotube can be controlled from several tens of nanometers to several micrometers. Depending on the fabrication, the diameter and length of the carbon nanotube can be controlled. In general, the wavelength band that can resonate or be absorbed on the length of the carbon nanotube ranges from the ultraviolet band to X-ray band. And X-rays are not usually absorbed by living bodies. By effective and selective irradiation of X-ray from the carbon nanotube injected to the desired region, local temperature can be raised through the microscopic coil of the aforementioned carbon nanotube.

Because, like inductance, current that is opposite to the entering magnetic field can also be induced, the induced current can in fact elevate the temperature in the case of electromagnetic waves that are longer than the length of carbon nanotube. That is, for electromagnetic waves with a longer wavelength than that of the soft X-ray, the temperature elevation effect can be maintained using the helical microscopic coil of carbon nanotube. For example, the temperature elevation effect is possible by the induced current from the irradiation of general visible light or infrared microwaves.

Therefore, the wavelength that can be irradiated in the body and is favorable for local heating can be chosen from such wide wavelength band of the electromagnetic wave, and can be utilized as a combination therapy with other treatment.

At present, a great deal of research is underway domestically and internationally for the art of synthesizing carbon nanotubes. The first synthesis success employed an arc-discharge method, but the yield was low. The synthetic method using lasers has been also studied a great deal.

The most studied method recently is the use of a catalyst, which can synthesize a large volume of carbon nanotubes inexpensively. The carbon nanotube in the microscopic coil shape

that can be used for local heating therapy is mostly produced by a synthetic method using lasers. A defect is induced to form a spiral shape instead of a straight line shape, and this defect is induced by a low temperature synthesis process. The carbon nanotube produced at low temperature usually has the characteristics of a conductor. That is, a microscopic carbon nanotube coil is formed, which has the properties of a conductor and a helical antenna shape.

Figure 2 shows the example for the synthesis of a carbon nanotube using a general catalyst. Figure 3 depicts the example for the synthesis of a carbon nanotube in microscopic coil form that is used for local heating device in the present invention.

The length and diameter of this carbon nanotube microscopic coil vary depending on the synthesis conditions and time. When the synthesis time is lengthened under the same synthesis conditions, the length of the microscopic coil formed becomes longer. The length of this carbon nanotube microscopic coil is directly related to the electromagnetic waves and can be controlled relatively easily.

The carbon nanotube is known to have a structure where one face of the graphite is basically in this direction, and it is judged that the carbon nanotube is not harmful to humans. Recently, investigations have been undertaken to develop a method that can attach a chemical radical to the end of the carbon nanotube. Such a chemical radical can be connected to a desired chemical through a proper buffer. Using such methods, an anticancer agent or a functional group that can attach to the cancer cells can be added to give a form with more complex functions.

One potential development is to store the carbon nanotube and anticancer agent in a nano-size microscopic capsule, so that the combined functions with the anticancer agent can be improved. After storing the carbon nanotube and anticancer agent in the nano-size microscopic capsule, it is injected into human body. When the injected microscopic capsule reaches the proper location, electromagnetic waves are irradiated to open the microscopic capsule by heating the carbon nanotube microscopic coil. Therefore, the heating action and the action of the anticancer agent take place at the same time.

In addition, for the transportation method of such a nano-size microscopic capsule to a desired location of the body, active research has been undertaken using nano-transport with a battery in a living body.

#### Effect of invention

As described above, with the local heating device using carbon nanotube of the present invention and following the directions for its use, the present invention has an advantage of elevating the temperature of the desired local section by inserting the helical microscopic coil of carbon nanotube into the body, and by irradiating electromagnetic waves of a the wavelength

that can generate resonance or induced electromotive force on the inserted carbon nanotube microscopic coil.

### Claims

1. A local heating device using carbon nanotube, which characteristically includes a transportation means that can deliver the helical microscopic coil of carbon nanotube; and an electromagnetic wave radiating means that can irradiate electromagnetic waves of a certain wavelength onto the aforementioned transportation means so that heat can be generated at the local section of the body where the above transportation means is delivered.
2. A local heating device using carbon nanotube claimed in Claim 1, wherein the transportation device that delivers the aforementioned carbon nanotube microscopic coil in the body is characteristically a nano-size microscopic capsule.
3. A local heating device using carbon nanotube claimed in Claim 2, wherein the aforementioned nano-size microscopic capsule is formed to be opened by the heat generated from the aforementioned carbon nanotube microscopic coil and to supply the content transported by the aforementioned microscopic capsule in the body.
4. A local heating device using carbon nanotube claimed in Claim 3, wherein an anticancer agent is furthermore provided in the aforementioned nano-size microscopic capsule. /6
5. A local heating device using carbon nanotube claimed in Claim 1, wherein the aforementioned electromagnetic wave radiating device characteristically irradiates electromagnetic waves of a wavelength that can generate heat by resonating with the aforementioned carbon nanotube microscopic coil.
6. A local heating device using carbon nanotube claimed in Claim 5, wherein the wavelength irradiated by the aforementioned electromagnetic wave radiating device is characteristically the wavelength of X-ray and ultraviolet band.
7. A local heating device using carbon nanotube claimed in Claim 1, wherein the aforementioned electromagnetic wave radiating device characteristically irradiates electromagnetic waves of a wavelength that can generate heat by inducing electromotive force on the aforementioned carbon nanotube microscopic coil.
8. A local heating device using carbon nanotube claimed in Claim 7, wherein the wavelength of the electromagnetic wave irradiated by the aforementioned electromagnetic wave radiating device is characteristically the wavelength of the far-infrared band, microwaves, and ultrasound waves. /6
9. A local heating device using carbon nanotube claimed in Claim 1, wherein the helical microscopic coil of carbon nanotube transported in the body by the aforementioned transportation means is formed to be attached to a chemical radical.

10. A local heating device using carbon nanotube claimed in Claim 9, wherein the chemical radical attached to the aforementioned carbon nanotube microscopic coil is characteristically an anticancer agent of a functional group that can be absorbed by cancer cells.

11. Directions for use of the local heating device using carbon nanotube, which includes a step where the microscopic coil of carbon nanotube is inserted into the transportation means;

a step where the transportation means is injected into the body so that the carbon nanotube can arrive at a desired location in the body; and

a step where a certain wavelength of electromagnetic waves is irradiated on the microscopic coil of carbon nanotube to generate heat at the microscopic coil of the carbon nanotube so that the temperature of the local region in the body can be elevated. /7

### Figures

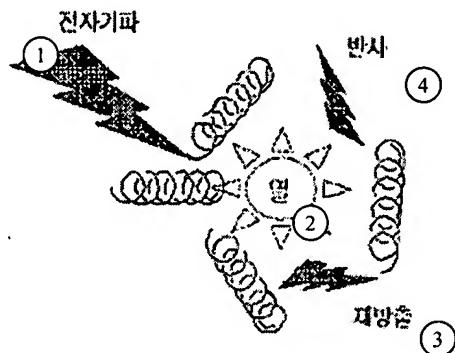


Figure 1

- Key:
- 1 Electromagnetic wave
  - 2 Heat
  - 3 Reflection
  - 4 Re-emission

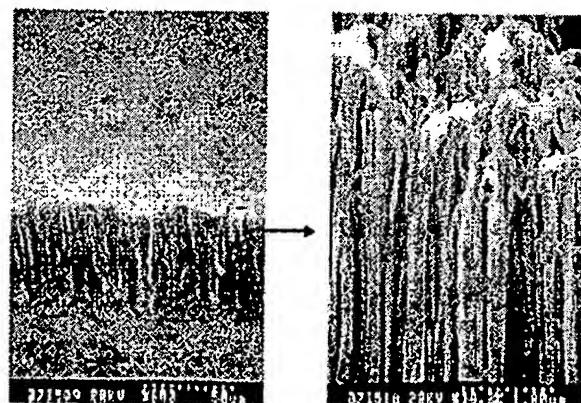


Figure 2

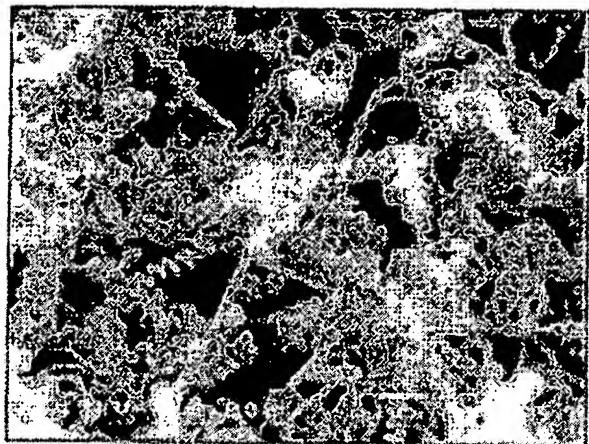


Figure 3